Chapter 7: Fugitive Dust Area Sources

LESSON GOAL

Demonstrate, through successful completion of the chapter review exercises, a general understanding of the methods used in the NEI to estimate PM emissions from agricultural tilling, paved and unpaved roads, and construction activities.

STUDENT OBJECTIVES

When you have mastered the material in this chapter, you should be able to:

1. Explain how PM emissions are calculated for agricultural tilling operations.
2. Identify methods for improving the NEI emissions for agricultural tilling operations.
3. Explain how PM emissions are calculated for paved and unpaved roads.
4. Identify methods for improving the NEI emissions for paved and unpaved roads.
5. Explain how PM emissions are calculated for residential, commercial, and road construction activities.
6. Identify methods for improving the NEI emissions for residential, commercial, and road construction activities.

Chapter 7: Fugitive Dust Area Sources

This Chapter addresses fugitive dust emissions from the following area sources: agricultural tilling, paved roads, unpaved roads, and residential, commercial, and road construction activities.

7.1 AGRICULTURAL TILLING

7.1.1 NEI Method

The SCC that is contained in the National Emissions Inventory for agricultural tilling emissions is 2801000003. For this category the NEI contains estimates of filterable PM_{10} and $PM_{2.5}$. There are no condensibles associated with this category.

The activity data for the NEI was obtained from the Conservation Technology Information Center (CTIC), which publishes a national crop residue management survey every two years that contains county level activity data. The NEI used the data from the 1998 survey. This database provides acres of crops tilled in each county by crop type and by tilling method. The five tilling methods included in the database include no till, mulch till, rich till, zero to 15% residue, and 15-30% residue.

The emission factor in the NEI is expressed as the mass of the total suspended particulate per acre tilled. The emission factor is comprised of a constant of 4.8 pounds per acre pass of PM, the silt content of the surface soil, the number of tillings per year, which is broken into conservation and conventional use, and the particle size multiplier to calculate the PM_{10} or the $PM_{2.5}$ from the PM emissions.

The silt content values that are used for various soil types in the NEI are listed in Table 7-1. These soil types are assigned to counties by using the USDA surface soil and county level maps to match the soil types to counties.

Table 7-1. NEI Silt Content Values

Soil Type	Silt Content (%)
Silt Loam	52
Sandy Loam	33
Sand	12
Loamy Sand	12
Clay	29
Clay Loam	29
Organic Material	10-82
Loam	40

Table 7-2 shows the number of tillings that are assumed by crop type for both conservation and conventional use. The no till, mulch till, and ridge till methods come from the county level inventory from the CTIC and are grouped into the conservation use category. The acres reported for the zero to 15 percent residue and the 15 to 30 residue are grouped into the conventional use category. As can be seen from the data in Table 7-2, the conventional use category has more tilling passes per acre than the conservation use.

Table 7-2. Number of Tillings in NEI

Crop	Conservation Use	Conventional Use
Corn	2	6
Spring Wheat	1	4
Rice	5	5
Fall-Seeded Small Grain	3	5
Soybeans	1	6
Cotton	5	8
Sorghum	1	6
Forage	3	3
Permanent Pasture	1	1
Other Crops	3	3
Fallow	1	1

Equation 7-1 presents the equation that is used in the NEI for calculating total PM emissions from agricultural tilling operations.

Equation 7-1. Agricultural Tilling Emission Estimation Equation

$$E = c*k*s^{0.6}*p*a$$

where: E = PM emissions, lbs per year
c = constant 4.8 lbs/acre-pass
k = dimensionless particle size multiplier (PM_{10} = 0.21; $PM_{2.5}$ = 0.042)
s = silt content of surface soil (%), defined as the mass fraction of particles smaller than 75 μm diameter found in soil to a depth of 10 cm
p = number of passes or tillings in a year
a = acres of land tilled

This equation has been used to estimate PM emissions from agricultural operations in the NEI prior to 1999. Since 1999 the number of acres tilled for each of the five tillage types has been estimated based on a linear interpolation of national level data available for 1998, 1999 and 2002. Using 1998 as the basis, national growth factors were developed by tillage type for 1998, 1999 and 2002. These growth factors were applied to county level emissions for 1998 to estimate county level emissions for 1999 and 2002. Finally, the NEI emission calculation assumed no controls.

7.1.2 Improving the NEI

One way to improve upon the NEI method is to use crop-specific acreage and tilling practice data from the state or local agency or tribal authority. In addition, if State or local emission factors exist, they should be used. Another improvement is to perform a field study to determine the local silt content percentage of the surface soil. The silt values that are used in the NEI are based on limited data and represent averages for the entire country. Local or state conditions may exist that warrant improving the NEI silt content values. Finally, the development of crop calendars to determine the time and frequency of the activities (e.g., land preparation, planting and tilling) will be an improvement over the NEI data.

7.1.3 CARB Study

This discussion is based on the report "Computing Agricultural PM_{10} Fugitive Dust Emissions Using Process Specific Rates and GIS" by Patrick Gaffney and Hong Yu and presented at the National Emissions Inventory Conference in San Diego during April 2003 (download from the CHIEF web site).

The California Air Resources Board (CARB) prepared a statewide PM_{10} inventory for land preparation activities and harvest activities at the county level. The goals were to obtain current crop-specific acreage data, develop crop-specific temporal profiles or crop calendars, and to develop emission factors for all crops.

In developing the inventory CARB obtained county level crop-specific acreage data from the California Department of Food and Agriculture. This department generates the crop data every year by county, and it includes over 200 crops and 30 million acres.

CARB also developed crop calendars for the 20 most important crop types with importance based on the acreage and the potential emissions associated with each crop type. The crop calendars were used to define the temporal periods of farming operation activities for each of the crop types. Figure 7-1 is an example of a crop calendar for corn. These types of calendars are very informative in terms of identifying when specific activities occur. As an example, stubble disking for corn occurred in November and December with one pass across the field. In contrast, the NEI assumes these emissions are annual and does not apply any temporal adjustments.

Figure 7-1. Example Crop Calendar for Corn

Farming Operations	Crop Cycles Per Year	Passes Per Crop Cycle	Fraction of Acreage Per Cycle	Passes During Month											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Land Preparation															
Stubble Disc	1	1	1.0												
Finish Disc	1	1	1.0												
List & Fertilize	1	1	1.0												
Mulch Beds	1	1	1.0												
Planting	1	1	1.0												
Cultivation	1	2	1.0												
Harvesting	1	1	1.0												

Prior to preparing the statewide PM_{10} inventory for land preparation activities and harvest activities CARB used the AP-42 tilling emission factor of 4.0 lbs PM_{10}/acre-pass for all land preparation activities. For harvesting, CARB only estimated emissions for three crop types for which emission factors were available. In order to improve over the past approach CARB conducted field testing over a seven year period to develop emission factors for several different types of activities that are crop specific and operation specific.

These new data allowed CARB to develop the crop calendar that was discussed above.

Table 7-3 presents the land preparation emission factors that CARB developed for five different types of activities. These emission factors were used as surrogates for other land preparation activities such as wheat cutting where specific factors were not available.

Table 7-3. Land Preparation Emission Factors

Land Preparation	(lbs PM_{10}/acre-pass)
Root Cutting	0.3
Discing, Tilling, Chiseling	1.2
Ripping, Subsoiling	4.6
Land Planning & Floating	12.5
Weeding	0.8

Table 7-4 presents the harvest emission factors that CARB developed for three types of crops. These factors were assigned to over 200 crop types and adjusted using a division factor that was developed in consultation with the agricultural industry within the state. For example, wheat harvesting was assigned to another crop type, and then adjusted with a division factor. These adjusted factors were considered to be the upper limit of the emission factors for other crop types.

Table 7-4. Harvest Emission Factors

Harvest	(lbs PM_{10}/acre-pass)
Cotton Harvest	3.4
Almond Harvest	40.8
Wheat Harvest	5

7.2 PAVED ROADS

7.2.1 NEI Method

The SCC that is contained in the National Emissions Inventory for paved road emissions is 2294000000. For this category the NEI contains emission estimates for PM_{10} and $PM_{2.5}$.

7.2.1.1 Activity Data

The activity data used for the NEI for paved roads is vehicle miles traveled (VMT) on paved roads. Paved road VMT is estimated by subtracting the state and road type-level unpaved road VMT from the total state road type-level VMT. It is important to note that because the Federal Highway Administration uses different methodologies to calculate unpaved road VMT and total road VMT, there are a few instances (principally in western states) where the unpaved road VMT is higher than the total VMT. In this case, the unpaved VMT is simply reduced to equal the total VMT, and the paved roads are assumed to be zero.

The NEI estimates monthly paved road VMT by applying temporal allocation factors that were developed for the 1985 NAPAP study to the annual paved road VMT estimate.

7.2.1.2 Emission Factors

The December 2003 version of the emission factor equation in AP-42 only estimates PM emissions from resuspended road surface material. PM emissions from vehicle exhaust, brake wear, and tire wear are estimated using EPA's MOBILE6 model and are subtracted from the emission factor equation. Equation 7-2 presents the formula for calculating the paved road emission factor for all vehicle classes. It should be noted that the NEI used the pre-December 2003 version of the emission factor equation for estimating paved road emissions.

Equation 7-2. Paved Road Emission Factor Equation

$$PAVED = PSDPVD*(PVSILT/2)^{0.65}*(WEIGHT/3)^{1.5} - C$$

where: PAVED = paved road dust emission factor for all vehicle classes combined (grams per mile)
PSDPVD = base emission factor for particles of less than 10 microns in diameter (7.3 g/mi for PM_{10})
PVSILT = road surface silt loading
WEIGHT = average weight of all vehicle types combined (tons)
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear

The road surface silt loading varies according to the 12 functional roadway classifications that are contained in the NEI. For example, the silt loading for county maintained class roads is one gram per square meter. However for road types with an average daily traffic volume (ADTV) of less than 5,000 vehicles per day the silt loading is 0.2 grams per square meter. For road types exceeding the 5,000 ADTV (i.e., freeways) the silt loading is 0.015 grams per square meter. The national average vehicle weight is 6,360 pounds. Section 13.2.1 of AP-42 contains more information on determining appropriate silt loading factors.

Since the amount of fugitive dust emissions is a function of the amount of rain, the NEI makes an adjustment for precipitation. This is accomplished by multiplying the emission factor by a rain correction factor that is calculated by the formula in Equation 7-3. The precipitation data for the NEI was taken from one meteorological station representative of an urban area for each state. In this manner, the NEI developed emission factors on a monthly basis at the state and the road type level for the average vehicle fleet.

Equation 7-3. Precipitation Adjustment Equation

$$\text{Correction Factor} = 1 - (p/4N)$$

where: p = the number of days during the averaging period with greater than 0.01 inches of precipitation
n = the number of days within the averaging period (e.g., 365 for annual)

7.2.1.3 Emission Calculations

Equation 7-4 shows the formula used in the NEI to calculate PM_{10} emissions from paved roads from resuspended road surface material. PM emissions from vehicle exhaust, brake wear, and tire wear are estimated using EPA's MOBILE6 model. $PM_{2.5}$ are estimated by multiplying the PM_{10} emissions by a particle size multiplier of 0.25.

Equation 7-4. Paved Road Emission Calculation Equation

$$EM_{s,r,m} = VMT_{s,r,m} * EF_{s,r,m}$$

where: EM = PM_{10} emissions (tons/month)
VMT = vehicle miles traveled (miles/month)
EF = emission factor (tons/mile)
S = State
R = road type class
M = month

Equation 7-5 shows the equation for allocating the monthly paved road emissions at the state level to the county level.

Equation 7-5. County Level Allocation Equation

$$PVDEMIS_{X,Y} = PVDEMIS_{ST,Y} * VMT_{X,Y} / VMT_{ST,Y}$$

where: $PVDEMIS_{X,Y}$ = paved road PM emissions (tons) for county x and road type y
$PVDEMIS_{ST,Y}$ = paved road PM emissions (tons) for the entire state and road type y
$VMT_{X,Y}$ = total VMT (10^6 miles) in county x and road type y
$VMT_{ST,Y}$ = total VMT (10^6 miles) in entire State for road type y

7.2.1.4 Controls

The NEI methodology assumes that controls are only in place for urban and rural roads in serious PM non-attainment areas and for urban roads in moderate PM non-attainment areas. A control efficiency of 79% is applied in these areas. This value corresponds to vacuum sweeping on paved roads twice per month. There is also an accounting of rule penetration that varies by road type and the non-attainment area classification.

7.2.2 Improving the NEI

One method to improve the NEI is to obtain VMT data for both paved and unpaved roads. This is preferable to the NEI approach of subtracting the unpaved road VMT from the total VMT.

Also, local registration data may be available that represents the average weight of the vehicles. This is preferable to the use of the NEI default value, particularly since this variable is weighted most heavily.

Another option is to perform sampling to refine the value used for silt content. However, this can be resource intensive and should only be used if enough samples can be collected to give a good representation of the roads in the inventory area.

7.3 UNPAVED ROADS

7.3.1 NEI Method

The SCC that is contained in the National Emissions Inventory for unpaved road emissions is 2296000000. For this category the NEI contains emission estimates for PM_{10} and $PM_{2.5}$. There is no condensable material so the PM filterable (PM-FIL) is equivalent to PM primary (PM-PRI).

7.3.1.1 Activity Data

The activity data used by the NEI for unpaved roads is state level unpaved road VMT data that is available from the Federal Highway Administration. This data is allocated to counties by population. Due to the availability of specific activity for the local classes this calculation is done differently for urban and rural local functional classes (i.e., county maintained road types) than it is for the state and federally maintained roads.

Equation 7-6 shows the equation for calculating the vehicle mile traveled by road type.

Equation 7-6. Unpaved VMT Calculation Equation

$$\text{Unpaved VMT}_{\text{Roadtype}} = \text{Mileage}_{\text{Roadtype}} * \text{ADTV} * \text{DPY}$$

where: Unpaved $VMT_{Roadtype}$ = road type specific unpaved VMT (miles/year)
$Mileage_{Roadtype}$ = total number of miles of unpaved roads by functional class (miles)
ADTV = Average daily traffic volume (vehicle/day)
DPY = number of days per year

The non-local functional classes of roads tracked by the Federal Highway Administration include rural minor collector, rural major collector, rural minor arterial, rural other principal arterial, urban collector, urban minor arterial, and urban other principal arterial. Because there are no estimates of average daily traffic volume for the non-local roads, it is estimated from local urban and rural VMT and mileage data for the local roads (see Equation 7-7).

Equation 7-7. ADTV Calculation Equation

$$ADTV = VMT/Mileage$$

where: ADTV = average daily traffic volume for State and federally maintained roadways
VMT = urban/rural VMT on county-maintained roadways (miles/year)
Mileage = urban/rural state-level roadway mileage of county-maintained roadways (miles)

The total state unpaved VMT by road type is calculated by adding the non-local functional class VMT to local functional class VMT. The total state unpaved VMT is temporally allocated by month using NAPAP temporal allocation factors.

7.3.1.2 Emission Factor

Similar to the AP-42 emission factor equation for paved roads, the unpaved road emission factor equation only estimates PM emissions from resuspended road surface material. PM emissions from vehicle exhaust, brake wear, and tire wear are estimated separately, using EPA's MOBILE6, and are subtracted out of the emission factor equation. It should be noted that the vehicle exhaust, brake wear, and tire wear component is relatively much less for unpaved roads than for paved roads.

Equation 7-8 shows the AP-42 empirical equation that is used to calculate the unpaved road emission factor. It has some of the same variables as the paved road equation, but they are weighted differently. For example, there is more weight given to surface material silt content.

Equation 7-8. Unpaved Road Emission Factor Equation

$$EF = [k*(s/12)*(S/30)^{0.5}]/[(M/0.5)^{0.2}] - C$$

where: EF = size specific emission factor (pounds per VMT)

k = empirical constant (1.8 lb/VMT for PM10-PRI, 0.27 for PM2.5-PRI)
s = surface material silt content (%)
M = surface material moisture content (%)
S = mean vehicle speed (mph)
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear

Table 7-5 summarizes the NEI default emission factor input values and the source of the values. The web address for the surface materials silt content values links to a database for unpaved roads that provides all the supporting documentation that was used, including a database of state level silt content. It should be noted that the calculation of unpaved road emissions in the NEI used the pre-December 2003 AP-42 emission factor equation. This equation considers mean vehicle weight and, therefore, it is listed in Table 7-5. Also, it should be noted that the precipitation data is obtained from one meteorological station that is representative of rural areas since unpaved road activity is expected to be occurring in rural areas.

Table 7-5. NEI Default Emission Factor Input Values

Input	Source of Values
Surface Material Silt Content(s)	Average state-level sources available at **ftp://ftp.epa.gov/EmisInventory/ finalnei99ver2/criteria/documentation/ xtra_sources/**
Mean Vehicle Weight (W)	National average value of 2.2 tons (based on typical vehicle mix)
Surface Material Moisture Content (M_{dry})	1 percent
Number of days exceeding 0.01 inches of precipitation (p)	1. Precipitation data from one meteorological station in state is used to represent all rural areas of the state 2. Local climatological data available from National Climactic Data Center at **http://www.ncdc.noaa.gov/oa/ncdc.html**

7.3.2 Improving the NEI

Short of developing independent estimates, the NEI defaults should be reviewed for representativeness. Also, local data should be used when possible for the activity and emission factor. If resources are limited, the

focus should be on collecting data that represents local precipitation as well as actual local VMT estimates.

7.4 CONSTRUCTION

7.4.1 Overview

The SCCs that are contained in the National Emissions Inventory for the construction category are shown in Table 7-6. The NEI contains emission estimates for PM_{10} and $PM_{2.5}$ and there are no condensibles, so PM-PRI is equal to PM-FIL. The relative contribution of these three different types of construction to the 1999 NEI is listed in the last column of Table 7-6.

Table 7-6. SCCs for Construction

Category	SCCs	% Contribution
Residential	2311010000	5
Commercial	2311020000	40
Road	2311030000	55

7.4.2 Residential Construction

7.4.2.1 NEI

The NEI uses the number of acres disturbed per year as the activity data for residential construction. Since direct estimates of the number of acres disturbed are generally not available, the value for this activity is estimated through the use of housing start data that is available from the Bureau of the Census. These data are available as regional monthly housing unit start values. Data is also available at a national level for housing unit starts for the various classifications of housing. These classifications include 1-unit houses, 2-unit houses, 3-4 unit houses, and 5+ unit housing. These housing classifications are important because there are different numbers of acres disturbed for each type of housing. The regional housing unit starts for each of these categories is estimated using the fraction that is available at a national level as shown in Equation 7-9.

Equation 7-9. Regional Housing Unit Starts Estimation Equation

Regional HS = Total Regional HS*(National HS by Category/Total National HS)

where: HS = Housing Starts

Since these regional housing starts are on a monthly basis they are summed to obtain an annual total. The next step is to allocate these regional housing starts data to the county level. This is accomplished by using data on the annual number of building permits in each county for each housing unit classification. It should be noted that the building permit data should not be used to estimate housing starts but only to allocate housing starts to the county. This is because many times a building permit is issued but the dwelling is never constructed. In short, the housing start data is a more accurate estimate of what is really being constructed.

Also, the regional housing start data actually represents the number of units that were started. However, the number of structures is a better activity indicator of the number of acres that are disturbed. For example, the activity data for an apartment building with multiple units should reflect the structure as a whole (i.e., the number of acres disturbed in the building of the structure and not for each unit). Table 7-7 shows the correlation between residential structure starts and housing unit starts.

Table 7-7. Relationship Between Housing Units and Residential Housing Structures

Housing Unit Starts	Residential Structure Starts
1-unit	1 unit per structure
2- unit	2 units per structure
3-4 unit	3.5 units per structure
5+ unit	Region specific units per structure as calculated from building permits data

Equation 7-10 shows the equation for estimating the number of county residential housing structure starts based on the regional number of structure starts.

Equation 7-10. Residential of Structure Starts Estimation Equation

County SS = Regional SS*(County Bldg. Permits/Regional Bldg. Permits)

where: SS = Structure Starts

The number of acres disturbed and the duration of the construction activity vary depending on the size and type of the structure. The assumed values for both acres disturbed and duration are listed in Table 7-8. The basis behind these assumptions can be found in *Estimating Particulate Emissions from Construction Operation*, 1999.

Table 7-8. Assumed Values for Residential Construction

Type of Structure	Acres Disturbed	Duration of Construction
1-unit	¼ acre per building	6 months
2-unit	1/3 acre per building	6 months
Apartments	½ acre per building	1 year

The number of apartment structures is estimated by adding the number of 3-4 unit buildings and the number of 5+ unit buildings. Also, the number of 1-unit houses needs to be estimated separately for houses with a basement and those without a basement. This is because building a house with a basement requires that additional dirt be moved and this must be accounted for in the emission factor equation. The number of 1-unit houses without basements is estimated by multiplying the regional number of 1-unit structures by the regional percentage of one-family houses with basements and subtracting the product from the total number of 1-unit houses.

The amount of dirt moved for 1-unit houses with basements is estimated by multiplying the assumed average basement depth of 8 feet by the assumed value of 2,000 square feet of dirt moved per structure. An additional 10 percent is added to this value to account for footings and other back-filled areas adjacent to the basement.

Table 7-9 shows the emission factor data that the NEI uses to estimate the emissions on an acre-per-month basis. Also, $PM_{2.5}$ is assumed to be 20% of PM_{10}.

Table 7-9. NEI PM_{10} Residential Construction Emission Factors

Housing Category	Emission Factor (tons/acre/month)
1-unit housing with basement	0.011 (plus 0.059 tons/cubic yard of on-site cut/fill)
1-unit housing without basement	0.032
2-unit housing	0.032
Apartments	0.11

Equation 7-11 shows the equation that NEI uses to estimate PM_{10} emissions from 1-unit residential structures with basements and Equation 7-12 shows the equation used for one-unit structures without basements, as well as all two-unit structures. The same equation is used for apartments with the exception

that the emission factor of 0.11 tons/acre/month is used instead of the 0.032 tons/acre/month value.

Equation 7-11. PM_{10} Emission Estimation Equation for 1-unit Residential Structures with Basements

Emissions = (EF*B*f*m) + 0.059 tons PM_{10}/1000 cubic yards of cut/fill

where: EF = Emission factor (0.011 tons PM_{10}/acre/month)
B = number of housing starts with basements
f = buildings-to-acres conversion factor (1/4 acre per building)
m = duration of construction activity (months)

Equation 7-12. PM_{10} Emission Estimation Equation for 1-Unit Residential Structures without Basements and 2-Unit Residential Structures

Emissions = (EF*B*f*m)

where: EF = Emission factor (0.032 tons PM_{10}/acre/month)
B = number of housing starts with basements
f = buildings-to-acres conversion factor (1/4 acre per building)
m = duration of construction activity (months)

Controls in PM_{10} non-attainment areas are accounted for by applying a control efficiency of 50% for both PM_{10} and $PM_{2.5}$ emissions for all PM_{10} nonattainment areas. There is no adjustment made for attainment areas. The 50% value represents best available control methods on fugitive dust construction activities in the nonattainment counties.

In addition to accounting for the control measures, other adjustments are applied to the emission estimates for all three construction categories. These adjustments are for soil moisture content and silt content. Emissions are adjusted for soil moisture content by using average Precipitation Evaporation (PE) values according to Thornthwaite's Precipitation Evaporation Index. Equation 7-13 shows the formula for making this adjustment. This adjustment accounts for precipitation and humidity in a certain area and, as can be seen in the equation, the higher the PE the smaller the adjustment.

Equation 7-13. Soil Moisture Level Adjustment

Moisture Level Corrected Emissions = Base Emissions * (24/PE)

where: PE = Precipitation Evaporation value for county

Emissions are adjusted for the dry silt content in the soil of the area being inventoried. Equation 7-14 shows the formula for making this adjustment.

Equation 7-14. Silt Content Adjustment

Silt Content Corrected Emissions = Base Emissions * (s/100)

where: s = % dry silt content in soil for area being inventoried

7.4.2.2 Improving the NEI

Obtaining local data for new housing starts, or permits for additions or modifications to existing homes would be an improvement over the use of the NEI defaults. Another improvement is to develop a buildings-to-acres conversion factor for acres disturbed per construction unit as well as obtaining data on the seasonality of residential construction practices. Finally, obtaining local information on soil moisture content, silt content, and control efficiencies would be an improvement over the NEI default values.

7.4.3 Commercial Construction

7.4.3.1 NEI

Similar to the residential construction category, the NEI uses the number of acres disturbed each year as the activity representing fugitive dust emissions from commercial construction. The NEI developed a top-down inventory by using national level activity data on the dollar value of commercial construction. These data were then allocated to the county level.

The allocation of the national level expenditure data was performed by using two data sources: *Annual Average Employment for SIC 154*, Data Series ES202, Bureaus of Labor Statistics, 1999 and *Annual Average Employment for SIC 154, MarketPlace 3.0*, Dunn & Bradstreet, 1999. Two data sources were used because there were some data missing in the first database, and the Dunn & Bradstreet database was used to fill in the gaps. Specifically, the county proportion of the state total from the Dunn & Bradstreet database was applied to the state total from the BLS data base to estimate employment for counties where data were missing.

The dollar value activity data were converted to acres disturbed using a conversion factor of 1.6 acres/10^6 dollars. This conversion factor was applied to the estimated county-level construction valuation data.

The PM10-PRI emission factor for commercial construction is 0.19 tons per acre month. The $PM_{2.5}$ is assumed to be 20% of the PM_{10}.

Equation 7-15 shows the emission formula used in the NEI for calculating the PM emissions from commercial construction.

Equation 7-15 Emission Estimation Equation for Commercial Construction

$$Emissions = (EF*\$*f*m)$$

where: EF = Emission factor (0.19 tons PM_{10}/acre/month)
$ = dollars spent on nonresidential construction (millions)
f = dollars-to-acres conversion factor
m = duration of construction activity (assumed 11 months)

The emissions calculated from Equation 7-15are adjusted to reflect control measures that are in place in PM_{10} non-attainment areas. In addition to accounting for the control measures, adjustments are applied for soil moisture content and silt content using Equation 7-13 and Equation 7-14, respectively.

7.4.3.2 Improving the NEI

Improving the NEI results can be done by obtaining local information on number of acres disturbed per construction event or per construction dollar spent. Also information on location, average duration, and seasonality of commercial construction practices would be an improvement over the NEI default values. Finally, local information on soil moisture content, silt content, and control efficiency would result in improved emission estimates.

7.4.4 Road Construction

7.4.4.1 NEI

The NEI uses the number of acres disturbed as the activity data indicator for road construction. State level expenditure data for capital outlay for six road construction classification are available. These classifications include:

Interstate, urban
Interstate, rural
Other arterial, urban
Other arterial, rural
Collectors, urban
Collectors, rural

Because some of the activities that are included in the total state level expenditure data do not contribute to PM emissions, it was necessary to remove the expenditures for these activities. These activities include minor widening, resurfacing, bridge rehabilitation, safety, traffic operation and control, and environmental enhancement and other.

To obtain the activity data in terms of acres disturbed it was necessary to first convert the expenditure data to mileage and then to acreage. The NEI estimated the miles of new road constructed by applying conversion factors of $4 million dollars per mile of interstate, and $1.9 million dollars per mile for other arterial and collector roads. These conversion factors were based on

information obtained from the North Carolina Department of Transportation. The NEI then applied the conversion factors in Table 7-10 to convert to acres disturbed per mile of road activity level.

Table 7-10 Road Construction Conversion Factors

Classification	Conversion Factor (acres/mile)
Interstate, urban	15.2
Interstate, rural	15.2
Other arterial, urban	15.2
Other arterial, rural	12.7
Collectors, urban	9.8
Collectors, rural	7.9

The estimated acres disturbed are summed across all of the road types to estimate the total acres disturbed. The NEI allocates these state-level estimates of acres disturbed to the county-level by using housing start data. This is the same data that was developed for the residential construction category. This assumes that new road development is directly proportional to new housing starts.

The PM10-PRI emission factor for road construction is 0.42 tons per acre month. The $PM_{2.5}$ is assumed to be 20% of the PM_{10}.

Equation 7-16shows the emission formula used in the NEI for calculating the PM emissions from road construction.

Equation 7-16 Emission Estimation Equation for Road Construction

$$\text{Emissions} = (EF*\$*f1*f2*d)$$

where: EF = Emission factor (0.42 tons PM_{10}/acre/month)
$ = State expenditures for capital outlay on road construction
f1 = dollars-to-miles conversion factor
f2 = miles-to-acres conversion factor
d = duration of roadway construction activity (assumed 12 months)

The emissions calculated from Equation 7-16are adjusted to reflect control measures that are in place in PM_{10} non-attainment areas. In addition to accounting for the control measures, adjustments are applied for soil moisture content and silt content using Equation 7-13 and Equation 7-14, respectively.

7.4.4.2 Improving the NEI

Obtaining information on location and timing of road construction practices in the area is one way of improving on the NEI results. Also, obtaining local data on the number of miles constructed and the number of acres disturbed per project or per mile of road constructed is better than using the NEI default values that are based on expenditure data. Also, local data on the duration of the projects and information on private road construction activity (not included in the NEI) would represent improvements. Finally, obtaining information for making adjustments for soil moisture content, silt content, and control efficiency would be an improvement over the NEI default values.

Review Exercises

1. Which of the following variables is not included in the NEI emissions methodology for estimating emissions from agricultural tilling operations?
   a. silt content of soil
   b. acres of land tilled
   c. control measures
   d. number of passes

2. Which of the following would be an improvement over the NEI emissions methodology for estimating emissions from agricultural tilling operations?
   a. use of corn calendars
   b. performing a field study to determine silt content
   c. use of crop-specific acreage
   d. All of the above

3. In the paved roads category, the NEI contains emission estimates for _____.
   a. PM_{10}
   b. $PM_{2.5}$
   c. Condensable PM
   d. A and B

4. Which of the following is used as the activity data for paved roads in the NEI?
   a. total miles of road
   b. vehicle miles traveled
   c. road type class
   d. average vehicle weight

5. The assumed control measure for paved roads in the NEI is _____.
   a. wetting of the road
   b. the use of dust suppression materials such as oil
   c. vacuum sweeping
   d. All of the above

6. Which of the following sources of emissions from unpaved roads are estimated by EPA's MOBILE6.2 model?
   a. vehicle exhaust
   b. tire wear
   c. brake wear
   d. All of the above

7. In estimating the amount of dirt moved for 1-unit houses with basements, an additional _____ percent is added to the amount of dirt removed for the basement to account for footings and other back-filled areas adjacent to the basement.
   a. 5
   b. 10
   c. 15
   d. 20

8. A _____ Precipitation Evaporation value represents high precipitation and humidity and results in a _____ adjustment to the base emissions estimate.
   a. larger, larger
   b. smaller, larger
   c. larger, smaller
   d. smaller, smaller

9. Which of the following activities need to be removed from State-level road construction expenditures when developing an activity level for road construction activities?
   a. Resurfacing
   b. Bridge rehabilitation
   c. Minor road widening
   d. All of the above

10. Which construction category requires a two-step conversion to obtain the activity data of number of acres disturbed?
   a. commercial
   b. residential
   c. road
   d. All of the above

Review Answers

1. c. control measures
2. d. All of the above
3. d. A and B
4. b. vehicle miles traveled
5. c. vacuum sweeping
6. d. All of the above
7. b. 10
8. c. larger, smaller
9. d. All of the above
10. c. road